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WHAT ARE THE FACTORS THAT INFLUENCE THE USE OF ICT IN THE CLASSROOM BY TEACHERS? EVIDENCE FROM A CENSUS SURVEY IN MADRID *

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ABSTRACT: With the world becoming increasingly digitalized, ICT has a key role to play in the educational process. The aim of this research is to determine the personal characteristics of teachers, as well as those of the school and class environment, that make them more likely to use ICT in their classes. This research is especially interesting given that there is little pre-existing literature in this regard. For this purpose, we estimate a logistic model with data from the census survey for the Community of Madrid (2016-2017 academic year) of the individualized evaluation of students in the final evaluation of their fourth year of Compulsory Secondary Education for four different competences: Mathematics, social and civic competence, English and Spanish. Our results suggest that higher teacher motivation, greater use of ICT by students in school and at home and better-prepared teachers who require less ICT training is associated with more frequent use of ICT in the classroom in all four subjects. However, some of the determinants of the use of ICT differ according to the competence evaluated. Teachers working full time use ICT more frequently in the classroom, but only in Spanish and Mathematics. On the other hand, teachers with greater disruption of order in their class use ICT less frequently in social and civic competence and English. We also find that a lack of digital devices in the school is associated with lower uses of ICT in English, Spanish and Mathematics but is associated with a higher use in social and civic competence. Finally, we also find that private and semiprivate schools use more ICT than public schools in Mathematics, English and Spanish.

JEL Codes: I20, I21, O33
Keywords: Compulsory Secondary Education, ICT, classroom, teachers

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1. Introduction

The incorporation of Information and Communication Technology (ICT) into the educational process offers numerous advantages. The implementation of ICT is associated with greater student motivation thanks to the use of more attractive, entertaining and fun tools (Bullock, 2001; Tüzün et al., 2009). Likewise, new Information and Communication Technology enables greater interactivity in learning, with more opportunities for cooperation and an improvement in communication between teachers and students (Schulz et al., 2002). ICT also stimulates initiative and creativity (Allegra et al., 2001; Wheeler et al., 2002) and enables individualization and flexibilization of education (Abell, 2006). All these advantages, among others, should lead to an improvement in academic performance and the acquisition of competences by the students.

Knowing the potential advantages of the use of ICT, analysis of the factors that influence its use in the classroom by teachers is crucial. The aim of this research is to determine the personal characteristics of teachers, as well as those of the school and class environment, which make them more likely to use ICT in their classes. We estimate four logistic models (Mathematics, social and civic competence, English and Spanish) with data from the census survey for the Community of Madrid (2016-2017 academic year) of the individualized evaluation of students in the final evaluation of their fourth year of Compulsory Secondary Education.

Our research is novel and supposes a contribution to the previous literature for three fundamental reasons: (1) the scarce attention given in literature to date to the determining factors of the use of ICT by teachers, (2) the possibility of analyzing the potential differential determinants of use according to the assessed competence (Mathematics, social and civic, English, Spanish), and (3) the fact that it is an analysis of the use of ICT in the classroom in particular rather than at school or at home.

Our results suggest that the use of ICT in the classroom by teachers is influenced by variables of a personal nature (motivation and the need for ICT training), by variables related to the student (ICT use at home) and by the school climate (lack of digital devices and general ICT use in school). Some of the determinants are common among all the subjects, but we also find different results by subject for some of the studied variables.

The paper is structured as follows. Section 2 presents a review of previous literature about ICT and education followed by Section 3 which describes the data and variables used in the analysis and the methodological approach. Section 4 presents the results of the empirical analysis and, lastly, section 5 concludes with the final considerations.

2. Literature Review

The Coleman report (1966) presented one of the first analysis of the determinants of educational performance and initiated a line of research into the Economics of Education focused on the study of personal, school and family factors that affect educational quality. The subsequent emergence of ICT in schools and homes led to the need to include this quality factor in the analysis of the determinants of academic performance, as evidenced in the literature review carried out by Cox et al. (2004), Condie and Munro (2006) and Claro (2010).

As mentioned in the introduction, knowing that the use of ICT in the classroom can potentially have positive effects on the process of acquisition of skills of schoolchildren, research is called for that identifies the factors that determine the effective use of these new technologies of communication information in the classroom. The use of depends directly on the teachers, since they decide when and how technology gets used in the classroom.

Previous research in the field on the use of technology by teachers in the classroom categorises factors that affect the degree of use of ICT into two main groups: i) personal characteristics of teachers, and ii) external environment.

Personal characteristics of teachers

A teacher´s characteristics can influence the adoption of an innovation such as ICT (Rogers, 1995, Schiller, 2003). In this line of research, Drossel et al. (2017) carry out multiple regression analyses of the frequency of computer use by teachers for instruction in five countries (Netherlands, Denmark, Australia, Poland and Germany) based on the International Association for the Evaluation of Educational Achievement (IEA) and the study of International Computer and Information Literacy Study 2013 (ICILS). The authors find that antecedents concerning teachers' attitudes have more of an impact on the teachers´ use of ICT in the classroom than school characteristics or teacher collaboration on the process level. In the Czech Republic, Gerick et al. (2017) show using a multilevel approach with ICILS (2013) data that the self-efficacy of teaching staff plays a key role in implementing ICT in the lessons. Petko et al. (2018) build a structural equation model with data from a survey of 349 Swiss primary school and find that educational technology integration is dependent on the readiness of individual teachers based on perceived skills and beliefs.

External environment

Eickelmann et al. (2017) show by means of a multi-level regression model as well as a multi-level path model that characteristics at school level do play a major role in the integration of ICT into teaching and learning of Mathematics in the five educational systems analysed (Australia, Germany, the Netherlands, Norway and Singapore). In Germany, Gerick et al. (2017) find that pedagogical IT support seems to be crucial for the use of ICT in teaching. The authors also show that in Australia the participation of teaching staff in professional development activities can be identified as relevant for the

use of ICT in the class. Recently, Petko et al. (2018) find that the use of ICT in lessons is influenced by the educational technology resources in classrooms, the perceived importance of technology integration in the school, goal clarity, head teacher support, as well as formal and informal exchange among teachers.

Previous research has studied the characteristics that make teachers more likely to use ICT in the classroom. However, literature in this area is fairly limited, which highlights the need for continued research on this topic.

In addition to reviewing the scarce literature directly related to our research aim, we consider it important to devote a section to a review of some of the most relevant recent studies in Spain of the relationship between the use of ICT and academic performance. Although this is not the objective of this research, it is considered useful to contextualize the importance of ICT in the process of competency acquisition. In the case of Spain, the literature to date does not provide clear evidence of the impact on academic performance of the use of ICT by students.

In Spain, Choi and Calero (2013) find evidence that the proportion of computers with internet connection and the number of computers does not show statistically significant effects on academic performance. The authors point out the ineffectiveness of increasing the volume of computers in schools to reduce school failure. Contrary to these results, Cabras and Tena (2013) and Cordero et al. (2015) show a positive effect of having computers in schools for educational purposes, especially in more unfavourable socio-economic groups. However, the authors emphasize the need to equip the centres with computers, but only with the accompaniment of a strategy that encourages use for teaching purposes.

More recently, Mediavilla and Escardíbul (2015) conclude that a longer time spent using ICT to perform school tasks has a negative effect on the academic performance of the subjects evaluated in PISA, while the greater use of computers as entertainment and the use of ICT at an earlier age leads to improvements in the acquisition of skills. Escardíbul and Mediavilla (2016) also find the impact of ICT on academic performance to be greater in Mathematics than in Science and Reading. More specifically, they find a positive impact of attitudinal variables towards computers and where ICT is used from an earlier age but a negative impact from excessive use of ICT. On the other hand, Vilaplana (2016) analyses the specific impact of the Escuela 2.0 program implemented in Spanish schools with the aim of favoring the introduction of new technologies and finds a positive net effect of the provision of ICT, albeit minor, delaying the divergence between repeating and non-repeating students.

Finally, in our previous research (Gómez-Fernández & Mediavilla, 2018) we found that a greater general use of ICT in schools is associated with a lower academic performance of students in Mathematics, Science and Reading. This result suggests the ineffectiveness of the implementation of ICT in the classroom. The results of our previous research explain our motivation for this research; to identify the typical profile of a teacher who implements ICT in the classroom and, from this, determine how to carry out a better implementation of ICT.

3. Data and methodological approach

3.1 Data: Individualized evaluations for Madrid

Individualized evaluations are carried out annually for all students in Spanish schools at the end of the third and sixth years of Primary Education and the fourth year of Compulsory Secondary Education. The purpose of these evaluations is to verify the degree of acquisition of linguistic and mathematical competences in all courses, science and technology competencies in the 6th grade, and social and civic competence in 4th year of ESO, as well as the achievement of the objectives of the educational stages. In addition to the test carried out by the students, the school director and teachers as well as the families and the students themselves complete a context questionnaire that is the central axis of this research. This questionnaire serves to evaluate the social, economic and cultural factors of the students and their families, and of the teachers and the school.

Throughout this research we use the census data of the context questionnaire carried out in the Community of Madrid in the year 2017 at the end of the fourth year of Compulsory Secondary Education. Madrid's students from all the public, semiprivate[2] and private schools of the Community of Madrid complete these tests. The use of census data is one of the main strengths of our research.

The questionnaire to teachers enables the date to be differentiated by subjects taught. Throughout this research we include teachers of English, Spanish, social and civic competence, and academic Mathematics. However, the teachers of applied Mathematics have not been included in our research, given that they are a minority and we do not consider that they are enough to be included in our estimates. Likewise, we have only included in our estimations the observations of the students who completed the evaluation of at least one competence and answered at least one of the questions in the context questionnaire. That is, those students who did not present any evaluated competence or who did not answer the context questionnaire have been eliminated.

3.2 Descriptive Analysis

The variables that have been considered for the econometric analysis are detailed in this section.[3] Table 1 shows the main descriptive statistics of the dependent and independent variables of our analysis as well as the percentage of missing values[4] that has been taken into consideration for the imputation (section 3.3).

[2] The school´s administration is private, but its financing is mostly public, along with specific contributions from parents whose children study in the center.

[3] Table A.1 of the Appendix presents the exact definition of each of the variables included in our estimations.

[4] The percentage of missing values of the explanatory variables of the teacher questionnaire has been calculated taken into consideration only the observations in which the dependent variable (use of ICT in class) does not show any missing value.

Being that the objective of our research is to clarify the determinants of the use of ICT in the classroom by teachers, the dependent variable is defined as "Use of ICT resources to carry out projects or do exercises in class". This variable is binominal, where a value of zero indicates that the ICTs are not used or only occasionally, while a value of one indicates that they are used frequently or always.

As explanatory variables we have used different information from the context questionnaire completed by teachers, students and school directors. The selection of explanatory variables has been carried out considering only those that could potentially have an impact on the use of ICT in the classroom.

From the teachers' questionnaire, we have included information on: (1) teacher's gender; (2) year of the teacher's birth; (3) ownership of the school; (4) time dedication; (5) Need for ICT training; (6) disturbances in the class; and (7) motivation. Regarding the student, we have included information about: (1) gender; (2) grade repetition; (3) use of ICT at home and in the school for schoolwork; (4) number of books at home; and (5) whether the student was born in Spain or abroad. Finally, from the school director questionnaire, we have considered three variables: (1) lack of a teacher training plan; (2) lack of autonomy to take decisions; and (3) lack of digital devices for teaching.[5]

Of the variables previously stated, the variable "Need for ICT training" is of special relevance for our research, given that we consider that it can be a key factor in explaining the use of ICT in the classroom. This variable is binominal, where a value of zero indicates that the teachers have no or very little need for ICT skills development, while a value of one indicates that the teacher has, to a greater or lesser extent, a need for ICT training. We thought it important to include in our regressions this variable about the need for training instead of the variable "training in ICT received in the last 12 months" given that we consider that the skills and confidence in the use of ICT nowadays is not just defined by training courses. It is the perception of need for development that is more adjusted to measure the ICT skills of the teaching staff.

The explanatory variables previously enumerated can be subdivided into two main groups: control variables and variables directly of interest. Those variables directly of interest are the ones we consider could be highly related to the use of ICT in the classroom: year of birth of the teacher, teachers' ICT training needs, teachers' motivation, lack of a teaching plan, lack of digital devices in the school, and ICT use by students at home and in the school for doing schoolwork.

[Table 1 around here]

The descriptive statistics show some relevant characteristics of the teachers and students regarding the variables of this research. We observe that most of the teachers use ICT in classes of Social and civic competence, English and Spanish. However, in Mathematics most of the teachers reported using ICT only occasionally and some reported never using ICT in their classes. Another very relevant result is that most of

[5] The correlation matrix between all the dependent and independent variables has been calculated. We have not included variables showing a correlation coefficient higher than 0.4.

the teachers indicate having, to a greater or lesser extent, the need for ICT skills development. This result is common for all the competences, albeit lower for Mathematics teachers probably because they use ICT less frequently in their classes. As for the motivation of the teachers, we observe that most of the teachers declare that they quite agree or strongly agree with the statement “If I could, I would continue to choose this job”. This result is similar among subjects. Finally, we observe that most of the students report using ICT frequently at home, but only sometimes in school.

3.3 Imputation

Regarding the missing values, table 1 shows that there are four explanatory variables with a percentage of missing values higher than 5% and whose imputation enables the sample of the final estimates to be increased: (1) lack of a teaching plan; (2) lack of autonomy; (3) lack of digital devices; and (4) repeater (students who repeat the year).

The initial sample for the four models estimated in this research - prior to the imputation - is of between 14.742 and 16.293 observations, this being taken from the total of observations of 31,259 students from the database of students who completed an evaluation of at least one competence and answered at least one of the questions in the context questionnaire.

To impute the missing values, we first explore the pattern of the missing values. However, we decide not to include the observations with missing values in the dependent variables (use of ICT in the class), and not to impute the values for the variables directly of interest in our research, such as “lack of a teaching plan” and “lack of digital devices”.

The analysis of the pattern confirms the suitability of the imputation of the two control variables with values of missing values higher than 5%: (1) lack of autonomy (16,18%) and (2) repeater (10,21%). Once the imputation of these two variables has been decided, the dichotomous correlation test is carried out between the variables to be imputed - with zero value for the missing values and value one for the valid values - and the rest of the original variables, as recommended by Carpenter et al. (2007). The results confirm the randomness (MAR - Missing at Random -, Rubin, 1976). Based on this, it is appropriate to proceed with the imputation.

In line with previous literature, the imputation is carried out using an iterative imputation method that imputes multiple variables by using chained equations (Van Buuren et al., 1999). The imputation through this technique involves a sequence of univariate imputation methods with fully conditional specifications of prediction equations (Royston and White, 2011). After considering the characteristics of the variables, we estimate the missing values from an empirical approach of an ordered logistic regression. For each missing value, 17 imputed observations have been generated (m = 17), considering that the variable "lack of autonomy" presents a maximum percentage of missing values of 16.18%.

The result of the imputation of the missing values is a gain of 1.659 observations on average, which implies an increase of the sample of around a 9%. That is, thanks to the imputation of the missing values, the total number of observations in the estimates has increased from 14.742 - 16.193 to a mean of 16.341 - 17.852 observations.

3.4 Methodology

To study the determinants of the use of ICT in the classroom, it is suitable to use maximum likelihood estimates (probit or logit, which employ normal distribution or logistics, respectively). In our case, we opted for the estimation of a logit because coefficients can be interpreted in terms of odds ratio. The binomial dependent variable " Use of ICT resources to carry out projects or do exercises in class " and the explanatory variables are those mentioned in the previous section and related to the school, student, family and teacher. According to Gujarati (2004) the mathematical formula of logit model is:

$$P_i = \frac{e^{z_i}}{1+ e^{z_i}} \qquad (1)$$

Where, P_i is the probability of using ICT in the class for the i_{th} student and it ranges from 0-1. z_i is a function of n-explanatory variables which is also expressed as:

$$Z_i = B_0 + \sum B_i X_i + U_i$$

i = 1, 2, 3, …., n
B_0 = intercept
B_i= regression coefficients to be estimated or logit parameter
U_i = a disturbance term, and
X_i= students', teachers', and schools' characteristics

According to Gujarati (2004), the coefficient of the logistic model result can be written in terms of the odds and log of odd ratio. The odds ratios facilitate the interpretation of the estimated coefficients. They indicate the ratio of the probability that the student will be using ICT in the class (P_i) to the probability that the student will not use ICT (1- P_i) and how this ratio changes when the value of a variable considered increases in one unit, keeping the others constant.

The formula of the probability that a student will not use ICT in the class is:

$$1 - P_i = \frac{1}{1+ e^{z_i}} \qquad (2)$$

The odds ratio can be written as the ratio between equation (1) and (2):

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{z_i}}{1 + e^{-z_i}} = e^{z_i}$$

An odds ratio greater than 1 indicates that the respective variable has a positive effect on the use of ICT in the class, while an odds ratio less than 1 indicates the opposite. The estimated odds ratio represents the factor that multiplies the probability of using ICT in

the class for the corresponding variable, when this takes a value of 1 (for discrete variables) or increases by one unit (for continuous variables) and the remaining variables stay constant.

4. Results

Table 2 shows the results of the estimated results for each of the evaluated competences. The results are expressed in odd-ratios.

The results show that there are four variables that are statistically significant in explaining the use of ICT in the classroom by the teacher in all the competences, and whose sign is unequivocal given that it coincides for the four subjects: (1) teachers' need for ICT training; (2) teachers' motivation; (3) use of ICT at home by students; and (4) use of ICT at school in general for doing schoolwork.

The results clearly show that those teachers who report considering having no or very little need for ICT training use more ICT in the classes than those who indicate a higher need of ICT skills development. This result is logical and indicates the importance of carrying out appropriate ICT training in schools to encourage the implementation of digital tools. However, we are aware of the limitations that the variable "need for ICT training" presents since it is self-perceived by the teaching staff and therefore could present a bias.

A very relevant result is the positive association between the motivation of teachers and their use of ICT in the classroom. Our regressions suggest that teachers that strongly agree with the affirmation "If I could decide again, I would continue to choose this job" are the ones who most use ICT in the classes. This result highlights the relevance of teacher motivation in promoting innovation in the classroom.

We also observe that if teachers have students in their class that use ICT at home, they use ICT more frequently in their classes than if they have a group of students who rarely use ICT at home. Students' characteristics seem to play a relevant role in determining the use of ICT by teachers.

Finally, the school climate also seems to play a relevant role. In those schools where students report frequently using ICT in general for doing schoolwork, teachers seem to be more predisposed to using ICT in their specific subject. This indicates that what other teachers do in their classes affects an individual teacher´s implementation of ICT. This emphasizes the relevance of the school climate.

In relation to the rest of the variables, we observe that they show a different association with the use of ICT in the class by teachers, depending on the competence evaluated. Thus, we find differential effects regarding the determinants of the use of ICT by teachers depending on the competence taught.

We observe that our results suggest that female teachers use ICT more frequently in the classroom than their male counterparts in Spanish and social and civic competence. However, it seems that men are more inclined to use ICT in the classroom than women

in Mathematics, while we observe no gender differences for English. The results also suggest that younger teachers frequently use ICT in the classroom more than older ones in social and civic competence, Spanish and Mathematics. However, in English older teachers are the ones who use ICT the most. Time dedication of the teachers also plays a relevant role in Spanish and Mathematics. Teachers working full time use more ICT than teachers working only part time. These results could indicate a higher involvement of full-time teachers in preparing the classes and innovating. Finally, the teachers who reported having a problem with disturbance in their class also reported a lower use of ICT in the classes than those who indicated not having problems at all with disrupting behaviours in social and civic competence and English.

Regarding the school climate, school ownership seems to be a relevant factor in Spanish, English and Mathematics. Public schools (reference category) show a lower use of ICT by teachers than private and semiprivate schools. We also observe that those teachers whose school director reported having a lack of digital devices use less ICT in the classroom in English, Spanish and Mathematics. However, this result is not observed in social and civic competence, where we find a positive association between the lack of digital resources and the use of ICT by teachers. The lack of a teaching plan in the school also seems to be a limitation to the use of ICT in the class in social and civic competence, English and Mathematics. However, our results suggest that the lack of autonomy favours the use of ICT in the class in English, Spanish and Mathematics.

[Table 2 around here]

As for the characteristics of the students and their families, we observe that the teachers who have students in their classes who reported having a high number of books at home use ICT more frequently in English. We also observe that classes with students who were not born in Spain show a lower use of ICT in class by English teachers. Regarding the gender of the students, this seems to be a significant variable only in Spanish and Mathematics. Classes with more (less) women are associated with a higher (lower) use of ICT in Spanish (Mathematics). Our results also suggest that having repeater students involves a lower use of ICT in English, but a higher use in social and civic competence. Finally, having immigrant students in the class affects negatively the use of ICT by teachers in English, but shows no association with its use in the other subjects.

5. Final Considerations

The analysis of the census data from the individualized evaluation of students in the final evaluation of their fourth year of Compulsory Secondary Education for the Community of Madrid (2016-2017 academic year) through a logistic model shows a correlation between the characteristics of the teachers, the students in their class and the schools, and the use of ICT in the classes of English, Spanish, Mathematics and social and civic competence. These results are relevant since they represent an important contribution due to the scarce literature on this subject to date.

We have obtained some results that deserve special attention. First, we find that those teachers with little or no need for ICT skills development are the ones that use ICT the most in their classes in the four competences evaluated in this research. This result, although logical, becomes relevant since it highlights the importance of implementing ICT training programs for teachers to encourage greater and better use of ICT and to take advantage of the potential benefits of these tools (Bullock, 2001; Allegra et al., 2001; Wheeler et al., 2002; Schulz et al., 2002; Abell, 2006; Tüzün et al., 2009).

Second, we observe that teachers' motivation seems to be a key aspect in explaining the implementation of ICT in the classroom in the four competences. This result is especially relevant, and it shows the importance of having teachers who appreciate their work and who would choose their profession again. As also suggested by previous research, we find therefore that the individual characteristics of the teachers matter (Rogers, 1995; Schiller, 2003; Drossel et al., 2017; Gerick et al., 2017) when we talk about ICT use in the lessons.

Finally, we find that students' characteristics are also relevant in explaining the frequency of use of ICT in the class by teachers. If teachers have classes with students that frequently use ICT at home and at school for doing schoolwork, they tend to use ICT in the class more than if their students use ICT less frequently at home and in school. These results indicate that students' familiarization with ICT matters for teachers. As well as these results common to all the subjects, we also find some differential associations between subjects. This distinction by subjects is one of the contributions of our research as there are no previous studies that distinguish by competence.

According to our results, teachers working full time use ICT in class more than teachers working part time, but only in Spanish and Mathematics. On the other hand, teachers with greater disruption of order in their class use ICT less frequently in social and civic competence and English. We also find that the lack of digital devices in a school is associated with a lower use of ICT by teachers in English, Spanish and Mathematics but is associated with a higher use in social and civic competence. Finally, we also find that the school ownership affects the use of ICT by teachers in all the evaluated competences, with the exception of social and civic competence. Our results indicate that private and semiprivate schools use more ICT than public schools.

All the results obtained in this research allow us to draw a typical profile of teachers who tend to use ICT more in their classroom. A motivated teacher trained in ICT who works in a school with digital devices available and in a classroom with students who frequently use ICT at home and at school, has a high predisposition (based on our results) to use ICT in his/her classes. The configuration of this profile is relevant as it can help guide educational policy measures aimed at increasing the presence of ICT in the classroom in order to take advantage of its potential benefits.

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Table 1: Descriptive statistics of the dependent and independent variables

Variable	Obs.	Mean	Std. Dev.	% Missing
	Teacher Questionnaire			
Social and civic Competence				
ICT use in class	21,462	0.632	0.482	0.00
Female	21,977	0.482	0.499	0.56
Year of birth	21,909	1,969.92	9.966	0.69
Semiprivate School	21,705	0.405	0.491	1.68
Private School	21,705	0.109	0.312	1.68
Time dedication	21,846	0.106	0.307	1.07
Need for ICT training	21,533	0.713	0.452	2.26
Disturbance of order in class	21,760	1.362	0.958	0.87
Motivation	21,789	2.504	0.734	1.23
English Competence				
ICT use in class	21,371	0.609	0.488	0.00
Female	21,930	0.799	0.401	0.21
Year of birth	21,823	1,972.22	9.237	0.48
Semiprivate School	21,671	0.421	0.494	1.43
Private School	21,671	0.104	0.305	1.43
Time dedication	21,819	0.090	0.286	0.77
Need for ICT training	21,581	0.799	0.401	1.68
Disturbance of order in class	21,427	1.654	0.939	1.52
Motivation	21,629	2.320	0.779	1.38
Spanish Competence				
ICT use in class	22,360	0.548	0.498	0.00
Female	22,923	0.710	0.458	0.13
Year of birth	22,869	1,971.41	9.063	0.46
Semiprivate School	22,771	0.442	0.497	0.90
Private School	22,771	0.095	0.293	0.90
Time dedication	22,794	0.078	0.269	0.80
Need for ICT training	22,500	0.800	0.400	1.79
Disturbance of order in class	22,671	1.460	0.941	0.89
Motivation	22,629	2.504	0.677	1.27
Mathematical Competence				
ICT use in class	22,719	0.275	0.447	0.00
Female	23,497	0.585	0.493	0.24
Year of birth	23,489	1,971.02	8.863	0.18
Semiprivate School	23,346	0.437	0.496	0.91
Private School	23,346	0.104	0.305	0.91
Time dedication	23,451	0.078	0.269	0.44
Need for ICT training	23,124	0.691	0.476	1.33
Disturbance of order in class	23,174	1.394	0.931	0.49
Motivation	23,188	2.493	0.689	1.05

	Director Questionnaire			
Lack teacher training	26,232	1.060	0.833	16.34
Lack autonomy	26,283	1.431	0.978	16.18
Lack tech. Devices	26,489	1.117	0.996	15.52
	Student Questionnaire			
Books at home	31,216	3.499	1.234	0.45
Female	31,259	0.516	0.499	0.31
Repeater	28,154	0.178	0.486	10.21
ICT use home	31,244	1.867	0.899	0.36
ICT use school	30,818	0.952	0.903	1.72
Immigrant	31,155	0.123	0.328	0.64

TABLE 2: Determinants of ICT use in the classroom by teachers

VARIABLES	(1) Social and civic	(2) English	(3) Spanish	(4) Mathematics
Female (Teacher)	**1.493**	0.962	**1.139**	**0.645**
	(0.034)	(0.044)	(0.036)	(0.037)
Year of birth (Teacher)	**1.027**	**0.979**	**1.016**	**1.004**
	(0.002)	(0.002)	(0.002)	(0.002)
Time dedication (Teacher)	1.037	0.920	**1.138**	**1.588**
	(0.059)	(0.060)	(0.062)	(0.064)
Need for ICT training (Teacher)	**0.902**	**0.958**	**0.939**	**0.963**
	(0.038)	(0.043)	(0.040)	(0.038)
Motivation (Teacher)	**1.406**	**1.210**	**1.502**	**1.294**
	(0.023)	(0.022)	(0.024)	(0.028)
Disturbance in class (Teacher)	**0.929**	**0.826**	0.967	1.031
	(0.018)	(0.019)	(0.017)	(0.020)
Semiprivate school (Teacher)	0.790	**1.219**	**1.091**	**1.384**
	(0.044)	(0.043)	(0.040)	(0.045)
Private school (Teacher)	0.950	**1.888**	**1.260**	**1.291**
	(0.065)	(0.074)	(0.064)	(0.068)
Public school (reference)	-	-	-	-
Lack of teacher training (Director)	**0.941**	**0.846**	**1.208**	**0.944**
	(0.023)	(0.023)	(0.022)	(0.035)
Lack of tech. devices (Director)	**1.054**	**0.862**	**0.874**	**0.755**
	(0.019)	(0.019)	(0.018)	(0.022)
Lack of autonomy (Director)	0.983	**1.117**	**1.065**	**1.120**
	(0.022)	(0.022)	(0.020)	(0.023)
Books at home (Student)	1.010	**1.051**	1.003	0.993
	(0.012)	(0.012)	(0.011)	(0.012)
Female (Student)	0.948	1.040	**1.988**	**0.904**
	(0.034)	(0.034)	(0.032)	(0.036)
Repeater (Student)	**1.084**	**0.820**	0.939	1.018
	(0.034)	(0.033)	(0.032)	(0.038)
ICT use at home (Student)	**1.137**	**1.139**	**1.085**	**1.086**
	(0.019)	(0.019)	(0.018)	(0.021)
ICT use at school (Student)	**1.375**	**1.371**	**1.482**	**1.592**
	(0.020)	(0.021)	(0.019)	(0.020)
Immigrant (Student)	0.952	**0.856**	0.982	1.000
	(0.052)	(0.052)	(0.049)	(0.058)
Observations	*16,590*	*16,341*	*17,522*	*17,852*

**Standard error in parentheses. Statistically significant values up to 5% level included appear in bold.*
** Results are expressed in odd-ratios.*

Appendix

Table A.1: Definition of dependent and independent variables

DEPENDENT VARIABLE	
Teacher questionnaire	
ICT use in class	0 = never, almost never or occasionally 1= frequently or in all cases
INDEPENDENT VARIABLES	
Teacher questionnaire	
Female	0 = male 1= female
Year of birth	Year number
Semiprivate School	0 = not semiprivate school 1= semiprivate school
Private School	0 = not private school 1= private school
Time dedication	0 = part time 1 = full time
Need for ICT training	0 = no or very little need for ICT skills development 1 = to some extent or a lot of need for ICT skills development
Disturbance of order in class	0 = not a problem 1 = slight problem 2 = moderate problem 3 = serious problem

Motivation	Degree of agreement / disagreement with the statement: "If I could decide again, I would continue to choose this job". 0 = nothing in agreement 1 = little bit of agreement 2 = quite agree 3 = strongly agree
School questionnaire	
Lack of a teacher training plan	0 = absolutely 1 = very little 2 = to some extent 3 = a lot
Lack of autonomy to decide	0 = absolutely 1 = very little 2 = to some extent 3 = a lot
Lack of technological devices for teaching	0 = absolutely 1 = very little 2 = to some extent 3 = a lot
Student questionnaire	
Female	0 = male 1 =female
Repeater	0 = never repeated 1 = repeated once 2 = repeated twice or more
Use of ICT at home for schoolwork	0 = never 1 = sometimes 2 = frequently 3 = every day or almost everyday

Use of ICT in the school for schoolwork	0 = never 1 = sometimes 2 = frequently 3 = every day or almost everyday
Books at home	0 = from 0 to 10 1 = from 11 to 50 2 = from 51 to 100 3 = from 101 to 200 4 = more than 200
Immigrant	0 = student was born in Spain. 1 = student was not born in Spain.

2013

2013/1, Sánchez-Vidal, M.; González-Val, R.; Viladecans-Marsal, E.: "Sequential city growth in the US: does age matter?"
2013/2, Hortas Rico, M.: "Sprawl, blight and the role of urban containment policies. Evidence from US cities"
2013/3, Lampón, J.F.; Cabanelas-Lorenzo, P-; Lago-Peñas, S.: "Why firms relocate their production overseas? The answer lies inside: corporate, logistic and technological determinants"
2013/4, Montolio, D.; Planells, S.: "Does tourism boost criminal activity? Evidence from a top touristic country"
2013/5, Garcia-López, M.A.; Holl, A.; Viladecans-Marsal, E.: "Suburbanization and highways: when the Romans, the Bourbons and the first cars still shape Spanish cities"
2013/6, Bosch, N.; Espasa, M.; Montolio, D.: "Should large Spanish municipalities be financially compensated? Costs and benefits of being a capital/central municipality"
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2013/9, Asensio, J.; Gómez-Lobo, A.; Matas, A.: "How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain"
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2013/11, Segarra, A.; García-Quevedo, J.; Teruel, M.: "Financial constraints and the failure of innovation projects"
2013/12, Jerrim, J.; Choi, A.: "The mathematics skills of school children: How does England compare to the high performing East Asian jurisdictions?"
2013/13, González-Val, R.; Tirado-Fabregat, D.A.; Viladecans-Marsal, E.: "Market potential and city growth: Spain 1860-1960"
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2013/17, Guío, J.M.; Choi, A.: "Evolution of the school failure risk during the 2000 decade in Spain: analysis of Pisa results with a two-level logistic mode"
2013/18, Dahlby, B.; Rodden, J.: "A political economy model of the vertical fiscal gap and vertical fiscal imbalances in a federation"
2013/19, Acacia, F.; Cubel, M.: "Strategic voting and happiness"
2013/20, Hellerstein, J.K.; Kutzbach, M.J.; Neumark, D.: "Do labor market networks have an important spatial dimension?"
2013/21, Pellegrino, G.; Savona, M.: "Is money all? Financing versus knowledge and demand constraints to innovation"
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2013/25, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"
2013/26, Lambertini, L.; Mantovani, A.: "Feedback equilibria in a dynamic renewable resource oligopoly: pre-emption, voracity and exhaustion"
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2013/29, Revelli, F.: "Tax limits and local democracy"
2013/30, Wang, R.; Wang, W.: "Dress-up contest: a dark side of fiscal decentralization"
2013/31, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"
2013/32, Saarimaa, T.; Tukiainen, J.: "Local representation and strategic voting: evidence from electoral boundary reforms"
2013/33, Agasisti, T.; Murtinu, S.: "Are we wasting public money? No! The effects of grants on Italian university students' performances"
2013/34, Flacher, D.; Harari-Kermadec, H.; Moulin, L.: "Financing higher education: a contributory scheme"
2013/35, Carozzi, F.; Repetto, L.: "Sending the pork home: birth town bias in transfers to Italian municipalities"
2013/36, Coad, A.; Frankish, J.S.; Roberts, R.G.; Storey, D.J.: "New venture survival and growth: Does the fog lift?"
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2014

2014/1, Montolio, D.; Planells-Struse, S.: "When police patrols matter. The effect of police proximity on citizens' crime risk perception"
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2015/40, Mancebón, M.J.; Ximénez-de-Embún, D.P.; Mediavilla, M.; Gómez-Sancho, J.M.: "Does educational management model matter? New evidence for Spain by a quasiexperimental approach"
2015/41, Daniele, G.; Geys, B.: "Exposing politicians' ties to criminal organizations: the effects of local government dissolutions on electoral outcomes in Southern Italian municipalities"
2015/42, Ooghe, E.: "Wage policies, employment, and redistributive efficiency"

2016

2016/1, Galletta, S.: "Law enforcement, municipal budgets and spillover effects: evidence from a quasi-experiment in Italy"
2016/2, Flatley, L.; Giulietti, M.; Grossi, L.; Trujillo-Baute, E.; Waterson, M.: "Analysing the potential economic value of energy storage"
2016/3, Calero, J.; Murillo Huertas, I.P.; Raymond Bara, J.L.: "Education, age and skills: an analysis using the PIAAC survey"
2016/4, Costa-Campi, M.T.; Daví-Arderius, D.; Trujillo-Baute, E.: "The economic impact of electricity losses"
2016/5, Falck, O.; Heimisch, A.; Wiederhold, S.: "Returns to ICT skills"
2016/6, Halmenschlager, C.; Mantovani, A.: "On the private and social desirability of mixed bundling in complementary markets with cost savings"
2016/7, Choi, A.; Gil, M.; Mediavilla, M.; Valbuena, J.: "Double toil and trouble: grade retention and academic performance"
2016/8, González-Val, R.: "Historical urban growth in Europe (1300–1800)"
2016/9, Guio, J.; Choi, A.; Escardíbul, J.O.: "Labor markets, academic performance and the risk of school dropout: evidence for Spain"
2016/10, Bianchini, S.; Pellegrino, G.; Tamagni, F.: "Innovation strategies and firm growth"
2016/11, Jofre-Monseny, J.; Silva, J.I.; Vázquez-Grenno, J.: "Local labor market effects of public employment"
2016/12, Sanchez-Vidal, M.: "Small shops for sale! The effects of big-box openings on grocery stores"
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